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Duane Arnold Energy Center

CEDAR RIVER OPERATIONAL ECOLOGICAL STUDY
ANNUAL REPORT

January 1995 - December 1995

Prepared by

Donald B. McDonald
Iowa City, Iowa

March 1996

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INTRODUCTION

This report presents the results of the physical, chemical, and biological studies of the Cedar River in the vicinity of the Duane Arnold Energy Center during the 22nd year of station operation (January 1995 to December 1995).

The Duane Arnold Energy Center Operational Study was implemented in mid-January, 1974. Prior to plant start-up extensive preoperational data were collected from April, 1971 to January, 1974. These preoperational studies provided a substantial amount of "baseline" data with which to compare the information collected since the station became operational. The availability of the 22 years of operational data, collected under a variety of climatic and hydrological conditions, provides an excellent basis for the assessment of the effects of the operation of the Duane Arnold Energy Center on the limnology and water quality of the Cedar River. Equally important is the availability of sufficient data to identify long-term trends in the water quality of the Cedar River which are unrelated to station operation, but are indicative of climatic patterns, changes in land use practices, or pollution control procedures within the Cedar River basin.

SITE DESCRIPTION

The Duane Arnold Energy Center, a nuclear fueled electrical generating plant, operated by the I. E. S. Utilities, Inc., is located on the west side of the Cedar River, approximately two and one-half miles north-northeast of Palo, Iowa, in Linn County. The plant employs a boiling water nuclear power reactor which produces approximately 560 MWe of power (1658 MWth) at full capacity. Waste heat rejected from the turbine cycle to the condenser circulating water is removed by two closed loop induced draft cooling towers which require a maximum of 11,000 gpm (ca. 24.5 cfs) of water from the Cedar River. A maximum of 7,000 gpm (ca. 15.5 cfs) may be lost through evaporation, while 4,000 gpm (ca. 9 cfs) may be returned to the river as blowdown water from the cool side of the cooling towers.

OBJECTIVES

Studies to determine the baseline physical, chemical, and biological characteristics of the Cedar River near the Duane Arnold Energy Center prior to plant start-up were instituted in April of 1971. These preoperational studies are described in earlier reports.[1-3] Data from these studies served as a basis for the development of the operational study.

The operational studies were designed to identify and evaluate any significant effects of chemical or thermal discharges from the generating station into the Cedar River, as well as to assess the magnitude of impingement of the fishery on intake screens or entrainment in the condenser make-up water. These were first implemented in January, 1974 and have continued without interruption through the current year.[4-24]

The specific objectives of the operational study are twofold:

1. To continue routine water quality determinations in the Cedar River in order to identify any conditions which could result in environmental or water quality problems.
2. To conduct physical chemical, and biological studies in and downstream of the discharge canal and to compare the results with similar studies executed above the intake. This will make possible the determination of any water quality changes occurring as a result of chemical additions or condenser passage, and to identify any impacts of the plant effluent on aquatic communities downstream of the discharge.

STUDY PLAN

During the operational phase of the study sampling sites were established in the discharge canal and at four locations in the Cedar River (Figure 1): 1) upstream of the plant at the Lewis Access Bridge (Station 1); 2) directly upstream of the plant intake (Station 2); 3) at a point within the mixing zone approximately 140 feet downstream of the plant discharge (Station 3); and 4) adjacent to Comp Farm, located about one-half mile below the plant (Station 4). Samples were also taken from the discharge canal (Station 5).

Prior to 1979, samples were collected and analyzed by the Department of Environmental Engineering of the University of Iowa. From January, 1979 through December, 1983 samples were collected and analyzed by Ecological Analysts, Inc. Since 1984 collection and analysis of samples has been conducted by the University of Iowa Hygienic Laboratory, located in Iowa City, Iowa. The conclusions contained in this annual report are based on the results of their analyses. Samples for routine physical, chemical, and biological analysis were taken twice per month, while other studies were conducted seasonally. The following are discussed in this report:

I. General Water Quality Analysis

A. Frequency: twice per month

B. Location: at all five stations

C. Parameters Measured:

1. Temperature
2. Turbidity
3. Solids (total, dissolved, and suspended)
4. Dissolved oxygen
5. Carbon dioxide
6. Alkalinity (total and carbonate)
7. pH
8. Hardness series (total and calcium)
9. Phosphate series (total and ortho)
10. Ammonia
11. Nitrate
12. Iron
13. Biochemical oxygen demand
14. Coliform series (fecal and *E. coli*)

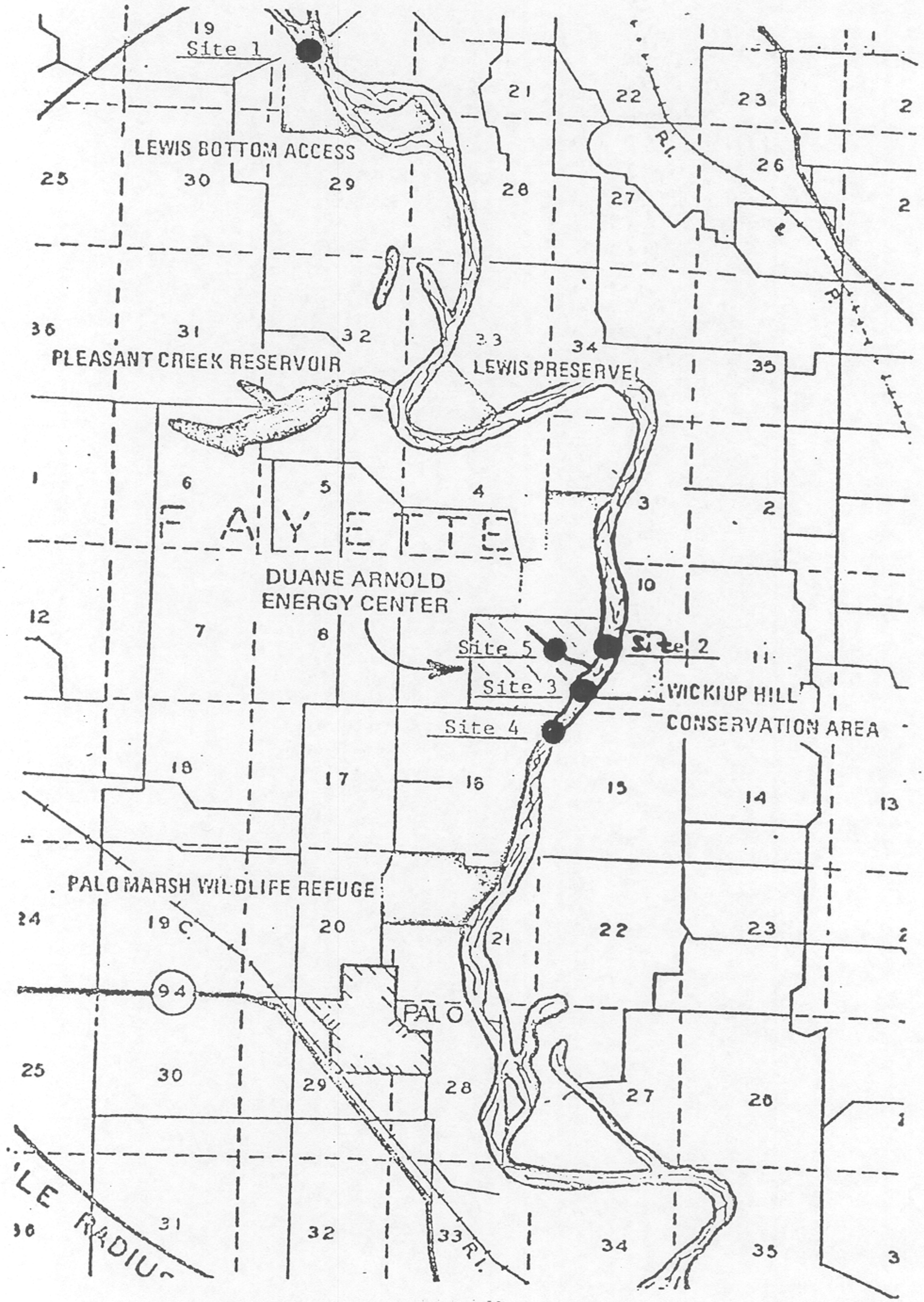

Figure 1. Location of Operational Sampling Sites

II. Additional Chemical Determinations

A. Frequency: twice yearly (April and July)

B. Locations: at all five stations

C. Parameters Measured:

1.	Chromium	5.	Mercury
2.	Copper	6.	Zinc
3.	Lead	7.	Chloride
4.	Manganese	8.	Sulfate

III. Biological Studies

A. Benthic Studies:

1. Frequency: spring and summer
2. Location: at all five stations

B. Impingement Studies:

1. Frequency: daily
2. Location: intake structure

C. Asiatic Clam (Corbicula) and Zebra Mussel (Dreissena) Surveys:

1. Frequency: three times yearly (May, June and September)
2. Location: upstream and downstream of the plant, intake bay, cooling tower basin, and discharge canal. The Zebra mussel survey also included Pleasant Creek Reservoir.

OBSERVATIONS

Physical Conditions

Hydrology (Table 1)

River flows during 1995 were similar to these present in 1994. Estimated mean flow for 1995 was 4384 cfs, slightly less than the average flow of 5273 cfs observed during the 24 years of the Cedar River water quality study. Mean monthly discharge at the U.S. Geological Survey gauging station in Cedar Rapids ranged from 1566 cfs in December to 9596 cfs in April. Flows were in excess of the 1961-1990 monthly median discharges in January, February, April through August and November. Lowest daily river flows occurred in December. A low flow of 1240 cfs was reported on December 30 while a maximum daily river discharge of 14,100 cfs occurred on April 27. River flows were relatively high in January and February ranging from 2020 to 5330 cfs. Flows increased in March and April to the yearly maximum of 14,100 cfs. Flows remained in excess of 6000 cfs through mid June and then declined to 3150 cfs by the end of July. A summer peak of 11,600 cfs occurred on June 3. Flows in August ranged from 2280 to 4070 cfs. Discharge declined in September falling to 1810 cfs by September 19. October flows were relatively constant ranging from 2020 to 2460 cfs. Flows generally declined in late November and December falling to 1240 cfs by December 30. Hydrological data are summarized in Table 1.

Temperature (Table 2)

Ambient upstream river temperatures during 1995 ranged from 0.0°C (32.0°F) to 28.5°C (83.3°F). The maximum ambient (Station 2) temperature was observed on August 14. This value was 2.0°C (3.6°F) above that observed in 1994[24] and somewhat higher than the 1980 to 1992 average maximum of 26.8°C (80.2°F). A maximum downstream temperature of 29.0°C (84.2°F) was also observed at Station 4 on August 14. The highest discharge canal (Station 5) temperature observed during the period was 30.0°C (86.0°F), was also recorded on August 14. Maximum temperature differentials (ΔT value) between the upstream river and the discharge canal (Station 2 vs. Station 5) of 13.5°C (24.3°F) were observed on October 17 and November 1.

Station operation continued to have a negligible effect on downstream water temperatures. The maximum ΔT value between ambient upstream temperatures at Station 2 and downstream temperatures at Station 3, located in the mixing zone for the discharge canal, of 1.0°C (1.8°F) was measured in November. Maximum temperature elevations at the Comp Farm station, one-half mile below the plant (Station 2 vs. Station 4) were also 1.0°C (1.8°F) in June and December. Obviously there was no instance in which a temperature elevation in excess of the Iowa water quality standard of 3°C[25] was observed. A summary of water temperature differentials between upstream and downstream locations is given in Table 3.

Turbidity (Table 4)

Average river turbidity values were the lowest observed since 1985 (Table 27). A peak value of 150 NTU occurred at the downstream river location on March 14. Low values (2-4 NTU) occurred in January, February and December. Turbidity values in the discharge canal were consistently higher than those observed in the upstream river. A maximum discharge canal turbidity of 158 NTU was observed on July 5.

Solids (Tables 5-7)
Solids determinations included total, dissolved, and suspended. Total solids values in upstream river samples were slightly higher than those observed in 1994.[24] Values ranged from 300 to 520 mg/L, with the majority falling between 350 and 450 mg/L.

Dissolved solids values were also slightly higher than those present in 1994. Upstream values ranged from 210 to 410 mg/L. Values of less than 250 mg/L occurred at intervals in March, August and September. High values continued to occur in the winter. As in most previous years, dissolved solids values at Station 3 and 4, downstream of the discharge canal, were slightly higher than values observed upstream. A maximum downstream value of 460 mg/L was observed at Station 3 on January 5.

Suspended solids values at river locations were generally similar to those of the previous year ranging from <1 to 280 mg/L. Low values occurred in January, February and December while highest values occurred during March.

As in previous years, total and dissolved solids values in the discharge canal were much higher than in the river samples. Maximum total solids concentrations of 2200 mg/L were observed in the discharge canal in mid June while a minimum value of 290 mg/L was observed in March. Most total solids values in the discharge canal were in excess of 1000 mg/L. Dissolved solids levels in the discharge canal ranged from 230 mg/L in early April to 1800 mg/L in mid June. Suspended solids values in the discharge canal were also consistently higher than those present at river locations but differences were not as apparent as they were in the case of total or dissolved solids.

Chemical Conditions

Dissolved Oxygen (Table 8)
Dissolved oxygen concentrations in river samples collected during 1995 were similar to those observed in 1994[24], ranging from 7.9 to 15.3 mg/L (98 to 142%

saturation). High dissolved oxygen concentrations (ca. 12-14 mg/L) continued to occur in the river in winter when temperatures were low and the solubility of the gas was highest, but supersaturated oxygen values were occasionally observed in the summer and autumn in conjunction with algal photosynthesis. Lowest dissolved oxygen values occurred from mid June through early August.

Dissolved oxygen concentrations in the discharge canal (Station 5) ranged from 3.7 to 11.9 mg/L (49 to 97% saturation). The lower dissolved oxygen values in the discharge canal did not impact downstream levels.

Carbon Dioxide (Table 9)
Carbon dioxide concentrations in river samples were usually somewhat higher than those present in 1994[24], ranging from <1 to 15 mg/L. From mid October through early December values were generally below 1 mg/L however maximum levels (9-15 mg/L) occurred in late December. Values in the discharge canal could not be precisely determined but, based on pH levels, were probably higher.

Alkalinity, pH, Hardness (Tables 10-14)
These interrelated parameters were influenced by a variety of factors, including hydrological, climatic, and biological conditions. Total alkalinity values in the 1995 river samples were similar to those present in 1994.[24] River values ranged from 120 to 264 mg/L. Lowest values occurred in September during a period of relatively low flow. Highest values occurred January and December.

Carbonate alkalinity was not present in river samples from January through June. A maximum value of 8 mg/L was observed in October in conjunction with increased algal activity.

Values for pH in river samples were lower than those observed in 1994[24], ranging from 7.7 to 8.6. Highest values occurred in October. As in previous years, highest levels accompanied increased photosynthetic activity while low values occurred in March and December.

Total hardness values in the upstream river were somewhat higher than those present in 1994[24] and generally paralleled total alkalinity levels. The highest values (350-440 mg/L) occurred during the winter and late fall, while low values of ca 175 mg/L occurred during a period of relatively low river flow in September.

Hardness values in the discharge canal continued to be consistently higher than upstream river values; a result of reconcentration in the blowdown. Total hardness levels in the discharge canal ranged from 205 to 1280 mg/L. Levels downstream of the station however were not generally higher than upstream values.

Calcium hardness values paralleled total hardness values. Concentrations ranged from 75 to 270 mg/L in the river and from 135 to 905 mg/L in the discharge canal.

<u>Phosphates</u> (Table 15 and 16)

Total phosphate concentrations in river samples were lower than those present in 1994[24]. Concentrations in the river ranged from <0.1 to 0.6 mg/L. High levels occurred in mid March. Low values, 0.1 mg/L or less, occurred in January, February and October. Levels in the discharge canal were consistently higher than those observed in the river. Discharge canal values ranged from 0.2 to 2.1 mg/L.

Orthophosphate concentrations in river samples were slightly lower than those present in 1994 rarely exceeding 0.1 mg/L. Values ranged from <0.1 mg/L to 0.3 mg/L.

<u>Ammonia</u> (Table 17)

Average ammonia concentrations in the river were lower than those observed in 1994[24]. Concentrations were below detection limits (<0.1 mg/L as N) from April through early November. Concentrations, 0.3 to 0.5 mg/L (as N) occurred from mid January through March and in December.

<u>Nitrate</u> (Table 18)

Average nitrate concentrations in the river increased slightly over 1994 values but were still below the levels observed between 1991 and 1993 (Table 27). During the current year nitrate values in upstream river samples ranged from 0.8 to 9.7 mg/L (as N). Maximum levels (>7 mg/L as N) occurred in

January and from April through mid July. Minimum levels occurred in September.

Nitrate concentrations were consistently higher in the discharge canal than in river samples. A maximum nitrate concentration of 34 mg/L (as N) was observed in the discharge canal on June 14. However downstream nitrate concentrations were similar to upstream levels.

Iron (Table 19)

Iron concentrations in the river were far higher than those present during 1994.[24] Concentrations in the river ranged from 0.11 to 9.9 mg/L. The maximum value was observed on March 14. Low values occurred in January and February. As in previous years, high iron concentrations were observed in association with increased turbidity and suspended solids, indicating that most of the iron present was in suspended form rather than in solution. Iron levels generally continued to be higher in the discharge canal. A maximum iron value of 9.3 mg/L was observed in the canal on July 5.

Biological Studies

Biochemical Oxygen Demand (Table 20)

Five day biochemical oxygen demand (BOD_5) values in the river were somewhat lower than those present in 1994[24] ranging from <1 to 11 mg/L and, averaging 4.0 mg/L in 1995 as compared to 5.3 mg/L in 1994 (Table 27). Highest values occurred in September and October in conjuction with algal blooms. Lowest values, <1 mg/L, occurred during the winter.

Coliform Organisms (Tables 21 and 22)

Coliform determinations included enumeration of fecal coliforms as well as specific determination of Escherichia coli.

Maximum river levels of fecal coliform and E. coli of 5,700 and 5,100 organisms/100 ml, respectively, were observed at the upstream location (Station 2) in mid July. Low values of 30 or less organisms/100 ml were usually observed in late fall and winter.

In May, August and September there were three instances when coliform concentrations at downstream locations were in excess of 200 organisms/100 ml above upstream locations. Sporadic instances of increased coliform levels at downstream locations were also observed in 1992 and 1994[22, 24] and these higher levels appear to be related to localized runoff rather than station operation.

Maximum fecal coliform and E. coli concentrations of 2,900 and 5,300 organisms/100 ml respectively were observed in samples from the discharge canal.

ADDITIONAL STUDIES

In addition to the routine monthly studies a number of seasonal limnological and water quality investigations were conducted during 1995. The studies discussed here include additional chemical determinations, benthic surveys, asiatic clam (Corbicula) and zebra mussel (Dreissena) surveys, and impingement determinations.

Additional Chemical Determinations

Samples for additional chemical determinations were collected on April 20 and July 5, 1995 from all river locations and from the discharge canal and analyzed for chlorides, sulfates, chromium, copper, lead, manganese, mercury, and zinc. Concentrations of all parameters fell within the expected ranges. Chloride and sulfate levels were similar at all river locations on both sampling dates to concentrations present in 1994.[24] Levels of the heavy metals chromium, lead and mercury were below detection limits in all samples. Copper concentrations of 20 ug/L were observed in the discharge canal on both sampling dates but copper concentrations in the river samples were all below the detection limit of 10 ug/L.

Zinc concentrations were low in all river samples ranging from 30 ug/L at the downstream DAEC location (Station 3) on July 5 to 20 ug/L or less in all other river samples. Manganese values in river samples were somewhat higher than those observed in 1994 ranging from 110 to 190 ug/L.

Reconcentration of solids in the blowdown discharge resulted in increased levels of chlorides, sulfates, manganese and zinc in the discharge canal in both the April and July samples. The high sulfate levels in the discharge canal on both sampling dates, 226 and 590 mg/L were also due in part to the addition of sulfuric acid for pH control in the cooling water. The results of the additional chemical determinations are given in Table 23.

Benthic Studies

Artificial substrate samples (Hester-Dendy) were placed at each of the four sampling locations upstream and downstream of the station and in the discharge canal on June 14 and August 1, 1995. These substrates were collected on July 17 and September 7, 1995 following a five week period to allow for the development of a benthic community.

As in previous years, the communities which developed on the substrates were far larger and more diverse than those which are normally found in the shifting sand and silt bottom characteristic of the Cedar River in the vicinity of the Duane Arnold Energy Center. A total of 32 taxa were identified during the two sampling periods, 30 in July and 21 in September. These included 28 species (7 orders) of insects, 1 specie of water mite, 1 specie of crustacean, 1 specie of snail and 1 specie of nematode. Midge (Chironomid) and various caddisfly (Trichoptera) larvae were the dominant organisms in both the July and September river samples. The numbers of organisms in the discharge canal were far lower than at the river locations. Diversity was also far lower in the discharge canal, 9 species in July and only 2 species in September.

In general, there continued to be little difference in the overall composition of the benthic populations between upstream and downstream locations, although the number of organisms varied considerably.

The total numbers of organisms were substantially higher at the Lewis Access location (Station 1) on both the July and September substrates.

As in previous years, the artificial substrate studies indicate the Cedar River, both upstream and downstream of the Duane Arnold Energy Center, is capable of supporting a relatively diverse macroinvertebrate fauna in those limited areas where suitable bottom habitat is available. The results of the benthic studies are given in Table 24.

Asiatic Clam and Zebra Mussel Surveys

In past years a number of power generation facilities experienced problems with blockage of cooling water intake systems by large numbers of Asiatic clams (Corbicula sp.). Although this clam commonly occurs in portions of the Iowa reach of the Mississippi River, it is normally absent from areas with shifting sand/silt substrates such as occur in the Cedar River in the vicinity of the Duane Arnold Energy center. Corbicula has not been collected from the Cedar River in the vicinity of the DAEC during the routine monitoring program, which was implemented in April of 1971. A single Corbicula was, however, collected in January of 1979 in the vicinity of Lewis Access, upstream of DAEC, by Hazelton personnel. Because Corbicula has been reported on one occasion from the Cedar River and is commonly found in power plant intakes on the Mississippi River, studies were implemented at the Duane Arnold Energy Center in 1981 to determine if the organism was present in the vicinity of the station or had established itself within the system. No Corbicula were collected during the 1981 to 1994 investigations.

The zebra mussel (Dreissena polymorpha) is a European form which was first found in the United States in Lakes St. Clair and Erie in 1988. The zebra mussel has been a major problem in water intakes in Europe for many years and is now causing significant problems at many power plant intakes as well as a number of municipal water treatment plants in the United States. The organisms tend to grow in clumps attached to a solid substrate and can rapidly clog intake structures, screens, and pipes. It is difficult to control chemically and frequently must be removed mechanically. The mussel is adapted to both river and lake habitats and does especially well in enriched waters which support large plankton populations that it utilizes as food. Unlike the Asiatic clam (Corbicula), it is capable of living in cold waters and does not require a silty substrate.

Since its introduction into the United States the zebra mussel has rapidly expanded its range. It is now found in all of the Great Lakes and in 1991, just three years after they were first found in the U.S., they were collected in the

Hudson, Illinois, Mississippi, Ohio, Susquehanna, Tennessee, and Cumberland Rivers.[26] The U.S. Army Corps of Engineers reports that zebra mussel populations have increased exponentially on lock and dam surfaces since their introduction into the Mississippi River in 1991[27,28] and it is now apparent that the organism also has established itself throughout the Iowa reach of the Mississippi River. Although it is impossible to make exact estimates, it is likely that the organism will continue to expand its range into the tributary streams of the Mississippi river within the nest few years. If it does colonize interior Iowa rivers, problems with intake structures at power plants in the area are likely to occur. As a result of these concerns, studies designed to detect the presence of the zebra mussel were first instituted in 1990. No zebra mussels were found during the 1990 to 1994 studies.[20,21,22,23,24]

Studies to determine the presence of both the Asiatic clam and the zebra mussel were conducted on May 17, June 1 and 14 and September 7 and 19, 1995. Inspection were made in the Cedar River both upstream and downstream of the Duane Arnold Energy Center as well as between the bar racks and traveling screens, in the cooling towers and in the discharge canal. Cement substrates were placed near the discharge structure in the Pleasant Creek Reservoir during May 1995 and were examined during both the June and September investigations to determine if colonization by zebra mussels had occurred. No Asiatic clams or zebra mussels were detected at any of the sites during the 1995 investigations.

Impingement Studies

The total number of fish impinged on the intake screens at the Duane Arnold Energy Center during 1995, as reported by Iowa Electric personnel, was somewhat lower than during 1994.[24] Daily counts indicated a total of 347 fish were impinged during 1995. Highest impingement rates continued to occur during the winter and early spring period. During the months of January to March and in November and December 292 fish, or approximately 84% of the yearly impingement total, were removed from the trash baskets. Lowest impingement rates occurred in June when only 1 fish was removed from the trash baskets. The month with the highest impingement rate was December, when 104 fish were collected in the trash baskets. The results of the daily trash basket counts are given in Table 25.

DISCUSSION AND CONCLUSIONS

The hydrological characteristics of the Cedar River during the 1995 study period were similar to those observed in 1994. Estimated mean discharge for the Cedar River at Cedar Rapids in 1995 was 4,384 cfs only slightly less than the average discharge of 5,273 cfs present during the 24 years of the Cedar River Water Quality and far below the extremely high flows experienced during 1993. As expected the water quality of the Cedar River in 1995 was similar to that present in 1994 and the impact of station operation on the water quality of the downstream river continued to be minimal.

In 1995 the maximum ΔT value between ambient upstream temperatures (Station 2) and temperatures one half mile downstream of the plant (Station 4) was only 1.0°C (1.8°F) and average downstream temperatures (Station 4) were only 0.4°C (0.7°F) above ambient (Table 26). Obviously this increase is below the Iowa Water Quality standard of 3.0°C (5.4°F)[25] and would not adversely impact the biota or water quality of the river.

Other parameters at downstream locations also exhibited little or no effects from the discharge of the Duane Arnold Energy Center. Of all parameters which were routinely determined during the 1995 study only one, dissolved solids, exhibited an increased mean value at the downstream locations. The mean upstream and downstream values of 322 and 337 mg/L respectively, constitute an increase of only 5%. In contrast to 1994 when mean downstream iron concentration values were 4% higher than upstream levels downstream values were actually 3% below those present upstream. Hardness, phosphate and nitrate concentrations were similar at the upstream and downstream location (Table 26). As in prior years studies conducted in April and July 1995 indicated that heavy metal values at downstream locations were not increased by station discharge, although increased concentrations of zinc and maganese were present in the discharge canal. Only sulfates, which are added to the cooling towers in the form of sulfuric acid for pH control, exhibited slight increases at downstream locations during both the April and July studies.

On three occasions during the 1995 study, fecal coliform concentration were over 200 organisms/100 ml above upstream levels. Sporadic instances of both increased downstream levels as well as higher upstream levels have been observed in past years. These conditions appear to be related primarily to localized runoff rather than activities at the Duane Arnold Energy Center. During the 1995 studies no violations of the Iowa Water Quality Standards[25] were observed which were the result of operation of the Duane Arnold Energy Center.

Although, in general, the water quality characteristics of the Cedar River in 1995 were similar to those present in 1994 some minor differences were apparent. Turbidity, phosphates, ammonia and BOD values were all somewhat lower during the current year than in 1994 (Table 27) as were the relative loading values, obtained by multiplying average annual concentrations by cumulative runoff (Table 28). Iron concentrations, however, were far higher in 1995 than in 1994 reaching the highest levels observed since the 1980's.[10-19] Although high iron concentrations usually accompany increased turbidity values, turbidity levels were relatively low in 1995 and the cause of the increased iron concentrations has not been determined.

Nitrate concentrations which declined in 1994 to the lowest levels observed since the drought year of 1989 appear to be increasing. The low nitrate levels observed in 1994 appeared to be primarily due to the flushing of much of the nitrate from the drainage basin during the period of extended high runoff present in 1993.

In recent years concentrations of phosphate and ammonia have been substantially lower than those present in the early 1970's.[1-5] In addition periods of high BOD levels associated with late winter and early spring runoff have become less common. These changes appear to be the result of modifications in farming and livestock production practices which have occurred over the last 20 years. Similar patterns have been observed in the Iowa River.[29]

During 1995 a total of 347 fish were impinged on the intake screens at the Duane Arnold Energy Center. This number is somewhat below that of the previous year and impingement continues to have an insignificant impact on the river fishery.

Benthic populations which developed on artificial substrates placed in the river in 1995 were similar to those observed in past years and indicate that the Cedar River is capable of supporting a diverse benthic community when adequate substrate is available. Although the total number of organisms continues to be higher at the upstream Lewis Access location (Station 1) than at other river locations, species diversity and composition was similar at all locations and it does not appear that station operation is adversely impacting the benthos of the river. In contrast to the river samples, diversity continues to be far lower on the discharge canal substrates.

Although no Asiatic clams or zebra mussels were detected during the 1995 study, the zebra mussel continues to expand its range and populations in the Mississippi River. It is recommended that monitoring for this form continue in order to institute appropriate control measures at the earliest sign of this organism in the vicinity of the Duane Arnold Energy Center.

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Table 1

Summary of Hydrological Conditions
Cedar River at Cedar Rapids*
1995

Date	Mean Monthly Discharge cfs	Percent of Median Discharge†
January	3092	247**
February	2939	179
March	5289	87
April	9596	143
May	8409	175
June	7418	136
July	4793	113
August	2983	122
September	2147	98
October	2187	88
November	2553	104
December	1566	83

*Data obtained from U.S. Geological Survey records
**In excess of the 75% quartile
†Based on 1961-1990 period.

Table 2

Temperature (°C) Values for the Cedar River near the Duane Arnold Energy Center During 1995

Date 1995	Upstream of Plant	Upstream of Plant Intake	Discharge Canal	140 Feet Downstream of Discharge	1/2 Mile Downstream from Plant
	1	2	5	3	4
Jan-05	0.0	0.0	2.0	0.5	0.0
Jan-17	0.5	0.5	6.0	0.5	0.5
Feb-02	0.5	0.5	6.5	0.5	0.5
Feb-16	0.0	0.0	2.5	0.0	0.0
Mar-02	0.0	0.0	10.5	0.5	0.5
Mar-14	9.0	9.0	10.5	9.0	9.5
Apr-04	6.5	6.0	8.0	6.0	6.5
Apr-20	10.0	10.0	15.0	10.0	10.0
May-04	11.5	11.5	21.0	11.5	12.0
May-17	16.0	16.0	17.0	16.0	16.0
Jun-01	17.5	17.5	18.0	17.5	17.5
Jun-14	20.0	20.0	26.5	20.5	21.0
Jul-05	21.0	21.0	26.0	21.0	21.5
Jul-17	26.0	26.5	27.5	26.5	27.0
Aug-01	26.0	26.0	26.5	26.0	26.5
Aug-14	28.0	28.5	30.0	28.5	29.0
Sep-07	22.0	21.5	25.0	22.0	21.5
Sep-19	16.5	16.0	22.0	16.5	16.5
Oct-04	15.0	15.5	24.0	15.5	16.0
Oct-17	11.0	11.5	25.0	11.5	12.0
Nov-01	6.0	6.0	19.5	7.0	6.5
Nov-16	2.0	2.0	6.0	2.0	2.0
Dec-04	1.0	1.0	3.5	1.5	2.0
Dec-20	0.0	0.0	2.5	0.0	0.5

Table 3

Summary of Water Temperature Differentials and Station Output During Periods of Cedar River Sampling in 1995

Date	ΔT(°C) Upstream River (Sta. 2) vs. Discharge (Sta. 5)	ΔT(°C) Upstream River (Sta. 2) vs. Downstream River (Sta. 3)	ΔT(°C) Upstream River (Sta. 2) vs. Downstream River (Sta. 4)	Station Output (% Full Power)
Jan-05	2.0	0.5	0.0	99.9
Jan-17	5.5	0.0	0.0	99.8
Feb-02	6.0	0.0	0.0	99.8
Feb-16	2.5	0.0	0.0	99.5
Mar-02	10.5	0.5	0.5	Off-line
Mar-14	1.5	0.0	0.5	Off-line
Apr-04	2.0	0.0	0.5	Off-line
Apr-20	5.0	0.0	0.0	34.0
May-04	9.5	0.0	0.5	99.9
May-17	1.0	0.0	0.0	8.4
Jun-01	0.5	0.0	0.0	5.4
Jun-14	6.5	0.5	1.0	99.9
Jul-05	5.0	0.0	0.5	99.8
Jul-17	1.0	0.0	0.5	99.8
Aug-01	0.5	0.0	0.5	99.9
Aug-14	1.5	0.0	0.5	99.9
Sep-07	4.5	0.5	0.0	99.9
Sep-19	6.0	0.5	0.5	99.9
Oct-04	8.5	0.0	0.5	99.9
Oct-17	13.5	0.0	0.5	100.0
Nov-01	13.5	1.0	0.5	100.0
Nov-16	4.0	0.0	0.0	100.0
Dec-04	2.5	0.5	1.0	94.8
Dec-20	2.5	0.0	0.5	100.0

Table 4

Turbidity (NTU) Values for the Cedar River
near the Duane Arnold Energy Center During 1995

Date 1995	Sampling Locations: Upstream of Plant	Upstream of Plant Intake	Discharge Canal	140 Feet Downstream of Discharge	1/2 Mile Downstream from Plant
	1	2	5	3	4
Jan-05	3	7	22	3	3
Jan-17	2	4	19	3	3
Feb-02	6	4	11	7	3
Feb-16	2	2	14	2	2
Mar-02	13	11	10	10	10
Mar-14	130	140	120	150	140
Apr-04	32	30	28	30	30
Apr-20	41	38	49	38	38
May-04	23	27	62	28	18
May-17	100	100	86	98	100
Jun-01	54	53	72	54	52
Jun-14	52	50	140	48	46
Jul-05	48	52	158	50	52
Jul-17	50	50	88	51	49
Aug-01	42	40	42	37	36
Aug-14	33	40	33	35	33
Sep-07	29	31	69	36	35
Sep-19	29	25	69	29	22
Oct-04	18	18	30	21	21
Oct-17	15	11	28	15	13
Nov-01	10	10	30	15	11
Nov-16	5	5	13	5	6
Dec-04	6	6	15	10	9
Dec-20	4	3	11	6	6

Table 5

Total Solids (mg/L) Values for the Cedar River near the Duane Arnold Energy Center During 1995

Date 1995	Upstream of Plant	Upstream of Plant Intake	Discharge Canal	140 Feet Downstream of Discharge	1/2 Mile Downstream from Plant
	1	2	5	3	4
Jan-05	430	430	1800	490	420
Jan-17	360	380	1300	420	430
Feb-02	380	390	1800	420	390
Feb-16	400	420	1800	420	390
Mar-02	300	300	290	300	300
Mar-14	510	520	450	520	510
Apr-04	410	410	400	420	410
Apr-20	420	420	640	410	420
May-04	440	430	1600	450	450
May-17	510	490	500	420	510
Jun-01	450	440	670	460	430
Jun-14	500	500	2200	510	490
Jul-05	480	490	1700	510	490
Jul-17	440	440	1900	470	460
Aug-01	470	420	1700	440	440
Aug-14	330	360	1600	370	380
Sep-07	330	320	1400	430	340
Sep-19	300	300	1300	370	310
Oct-04	350	350	1500	370	360
Oct-17	370	350	1800	380	370
Nov-01	380	380	1500	500	400
Nov-16	390	400	1400	400	400
Dec-04	390	406	930	420	420
Dec-20	420	420	1500	450	460

Table 6

Dissolved Solids (mg/L) Values for the Cedar River near the Duane Arnold Energy Center During 1995

	Sampling Locations				
Date 1995	Upstream of Plant	Upstream of Plant Intake	Discharge Canal	140 Feet Downstream of Discharge	1/2 Mile Downstream from Plant
	1	2	5	3	4
Jan-05	410	410	1700	460	420
Jan-17	360	370	1200	400	390
Feb-02	360	350	1700	390	380
Feb-16	380	370	1800	420	390
Mar-02	290	280	280	280	270
Mar-14	240	240	250	240	230
Apr-04	340	330	230	330	340
Apr-20	320	320	540	340	310
May-04	340	340	1400	340	330
May-17	300	300	320	310	280
Jun-01	300	290	460	300	300
Jun-14	340	350	1800	360	340
Jul-05	340	340	1400	360	390
Jul-17	310	310	1600	330	330
Aug-01	300	280	1500	310	310
Aug-14	230	240	1400	240	260
Sep-07	240	230	1300	310	260
Sep-19	220	210	1100	280	230
Oct-04	280	270	1300	290	280
Oct-17	300	310	1700	320	320
Nov-01	350	340	1400	450	370
Nov-16	360	370	1300	360	390
Dec-04	370	370	870	390	380
Dec-20	400	400	1400	420	420

Table 7

Suspended Solids (mg/L) Values for the Cedar River near the Duane Arnold Energy Center During 1995

	Sampling Locations				
Date 1995	Upstream of Plant	Upstream of Plant Intake	Discharge Canal	140 Feet Downstream of Discharge	1/2 Mile Downstream from Plant
	1	2	5	3	4
Jan-05	1	10	33	3	18
Jan-17	3	5	17	3	4
Feb-02	<1	2	10	4	3
Feb-16	<1	2	15	2	1
Mar-02	24	13	15	16	12
Mar-14	280	270	200	300	250
Apr-04	62	59	52	56	50
Apr-20	78	76	94	74	77
May-04	55	60	110	71	67
May-17	170	170	140	170	170
Jun-01	120	120	170	130	120
Jun-14	120	140	210	110	110
Jul-05	90	99	230	97	96
Jul-17	100	110	130	110	110
Aug-01	130	110	64	110	100
Aug-14	79	96	51	90	81
Sep-07	81	78	120	88	86
Sep-19	71	66	140	73	63
Oct-04	57	59	55	61	60
Oct-17	46	42	50	42	39
Nov-01	20	19	39	24	18
Nov-16	11	11	18	9	9
Dec-04	11	13	13	21	15
Dec-20	2	5	7	3	5

Table 8

Dissolved Oxygen (mg/L) Values for the Cedar River near the Duane Arnold Energy Center During 1995

Date 1995	Upstream of Plant	Upstream of Plant Intake	Discharge Canal	140 Feet Downstream of Discharge	1/2 Mile Downstream from Plant
	1	2	5	3	4
Jan-05	13.6	14.2	10.3	14.0	14.3
Jan-17	12.7	12.9	10.3	12.9	12.9
Feb-02	13.7	13.5	11.9	13.4	13.6
Feb-16	13.3	12.8	9.7	12.4	12.8
Mar-02	14.0	13.1	10.8	12.8	13.1
Mar-14	10.3	10.4	10.8	10.4	10.3
Apr-04	11.2	11.2	11.1	11.1	11.8
Apr-20	11.0	11.0	9.5	10.9	11.0
May-04	11.1	11.1	8.5	10.9	11.0
May-17	9.1	9.4	9.6	9.3	9.4
Jun-01	9.2	9.1	9.1	9.0	9.1
Jun-14	8.2	8.0	6.7	8.1	8.0
Jul-05	8.1	8.1	7.3	8.0	8.0
Jul-17	8.4	8.8	6.0	8.9	9.8
Aug-01	7.9	7.9	7.7	8.3	8.4
Aug-14	12.0	12.1	3.7	12.2	12.4
Sep-07	8.1	8.3	6.4	8.1	9.8
Sep-19	9.5	9.3	6.1	9.0	9.8
Oct-04	12.1	12.9	4.4	13.1	14.5
Oct-17	13.4	14.3	6.4	14.2	15.3
Nov-01	12.8	12.8	8.4	12.3	12.7
Nov-16	13.4	13.8	7.3	14.0	13.9
Dec-04	12.7	12.5	8.1	12.4	12.8
Dec-20	13.6	13.3	9.5	12.8	13.0

Table 9

Carbon Dioxide (mg/L) Values for the Cedar River
near the Duane Arnold Energy Center During 1995

Date 1995	Sampling Locations: Upstream of Plant	Upstream of Plant Intake	Discharge Canal	140 Feet Downstream of Discharge	1/2 Mile Downstream from Plant
	1	2	5	3	4
Jan-05	4	4	*	4	4
Jan-17	5	5	*	5	5
Feb-02	4	4	*	4	4
Feb-16	4	4	*	4	4
Mar-02	3	3	4	3	3
Mar-14	6	5	5	5	4
Apr-04	3	3	3	3	3
Apr-20	4	4	3	3	4
May-04	2	2	*	2	2
May-17	3	3	2	3	3
Jun-01	3	2	2	2	3
Jun-14	3	3	*	3	4
Jul-05	3	3	*	2	3
Jul-17	<1	<1	*	<1	<1
Aug-01	2	2	*	2	2
Aug-14	<1	<1	*	<1	<1
Sep-07	2	3	*	2	2
Sep-19	2	2	*	2	2
Oct-04	2	<1	*	<1	<1
Oct-17	<1	<1	*	<1	<1
Nov-01	<1	<1	*	<1	<1
Nov-16	<1	<1	*	<1	<1
Dec-04	<1	<1	*	<1	<1
Dec-20	15	12	*	9	9

*Unable to calculate

Table10

Total Alkalinity (mg/L-CaCO) Values for the Cedar River near the Duane Arnold Energy Center During 1995

Date 1995	Upstream of Plant	Upstream of Plant Intake	Discharge Canal	140 Feet Downstream of Discharge	1/2 Mile Downstream from Plant
	1	2	5	3	4
Jan-05	264	264	134	264	260
Jan-17	238	238	102	238	240
Feb-02	236	230	118	230	238
Feb-16	240	238	102	236	244
Mar-02	174	172	182	172	166
Mar-14	150	138	158	148	142
Apr-04	218	220	224	218	210
Apr-20	192	194	106	198	194
May-04	206	208	122	206	202
May-17	196	194	204	194	194
Jun-01	194	194	188	192	196
Jun-14	208	202	112	202	216
Jul-05	210	206	152	214	220
Jul-17	188	190	162	190	192
Aug-01	202	186	138	190	194
Aug-14	158	156	166	154	152
Sep-07	150	148	128	138	150
Sep-19	120	120	134	134	124
Oct-04	162	164	98	162	160
Oct-17	200	198	104	200	198
Nov-01	214	218	112	210	216
Nov-16	234	236	142	226	240
Dec-04	228	230	138	224	232
Dec-20	246	260	128	246	242

Table11

Carbonate Alkalinity (mg/L-CaCO) Values for the Cedar River near the Duane Arnold Energy Center During 1995

	Sampling Locations				
Date 1995	Upstream of Plant	Upstream of Plant Intake	Discharge Canal	140 Feet Downstream of Discharge	1/2 Mile Downstream from Plant
	1	2	5	3	4
Jan-05	<1	<1	<1	<1	<1
Jan-17	<1	<1	<1	<1	<1
Feb-02	<1	<1	<1	<1	<1
Feb-16	<1	<1	<1	<1	<1
Mar-02	<1	<1	<1	<1	<1
Mar-14	<1	<1	<1	<1	<1
Apr-04	<1	<1	<1	<1	<1
Apr-20	<1	<1	<1	<1	<1
May-04	<1	<1	<1	<1	<1
May-17	<1	<1	<1	<1	<1
Jun-01	<1	<1	<1	<1	<1
Jun-14	<1	<1	<1	<1	<1
Jul-05	<1	<1	<1	<1	<1
Jul-17	4	4	<1	8	8
Aug-01	<1	<1	<1	<1	<1
Aug-14	4	6	<1	6	4
Sep-07	<1	<1	<1	<1	<1
Sep-19	<1	<1	<1	<1	<1
Oct-04	<1	6	<1	6	6
Oct-17	6	6	<1	8	6
Nov-01	4	6	<1	4	4
Nov-16	4	4	<1	4	4
Dec-04	4	2	<1	2	2
Dec-20	<1	<1	<1	<1	<1

Table12

Units of pH Values for the Cedar River near the Duane Arnold Energy Center During 1995

Date 1995	Upstream of Plant 1	Upstream of Plant Intake 2	Discharge Canal 5	140 Feet Downstream of Discharge 3	1/2 Mile Downstream from Plant 4
	Sampling Locations				
Jan-05	8.3	8.3	8.1	8.3	8.3
Jan-17	8.2	8.2	8.1	8.2	8.2
Feb-02	8.3	8.3	8.2	8.3	8.3
Feb-16	8.3	8.2	8.1	8.2	8.2
Mar-02	8.3	8.3	8.1	8.3	8.3
Mar-14	7.8	7.8	7.9	7.9	7.9
Apr-04	8.3	8.3	8.2	8.3	8.3
Apr-20	8.1	8.1	7.9	8.2	8.1
May-04	8.3	8.3	7.8	8.3	8.3
May-17	8.1	8.1	8.3	8.1	8.1
Jun-01	8.2	8.2	8.2	8.2	8.2
Jun-14	8.1	8.1	7.8	8.1	8.0
Jul-05	8.1	8.2	7.9	8.2	8.1
Jul-17	8.4	8.4	7.7	8.4	8.4
Aug-01	8.3	8.2	4.5	7.8	8.3
Aug-14	8.4	8.4	7.5	8.4	8.5
Sep-07	8.1	8.0	7.8	8.1	8.2
Sep-19	8.1	8.2	7.7	8.2	8.2
Oct-04	8.3	8.4	7.4	8.5	8.6
Oct-17	8.4	8.4	7.6	8.5	8.6
Nov-01	8.4	8.4	7.9	8.4	8.5
Nov-16	8.4	8.3	7.9	8.4	8.4
Dec-04	8.4	8.4	8.0	8.4	8.4
Dec-20	7.7	7.8	7.6	7.9	7.9

Table13

Total Hardness (mg/L-CaCO) Values for the Cedar River near the Duane Arnold Energy Center During 1995

	Sampling Locations				
Date 1995	Upstream of Plant	Upstream of Plant Intake	Discharge Canal	140 Feet Downstream of Discharge	1/2 Mile Downstream from Plant
	1	2	5	3	4
Jan-05	345	365	1120	395	275
Jan-17	300	295	765	310	310
Feb-02	300	315	1120	335	325
Feb-16	320	330	1140	350	350
Mar-02	240	250	275	255	255
Mar-14	195	225	205	210	200
Apr-04	305	285	275	290	285
Apr-20	280	270	380	270	270
May-04	280	275	910	285	296
May-17	255	275	270	255	275
Jun-01	265	285	365	275	265
Jun-14	285	295	1280	295	300
Jul-05	300	310	1060	360	310
Jul-17	295	305	1060	330	340
Aug-01	310	320	990	320	320
Aug-14	255	225	925	250	235
Sep-07	185	185	775	230	195
Sep-19	175	175	695	205	175
Oct-04	225	215	835	235	215
Oct-17	195	215	610	215	215
Nov-01	425	380	1015	390	330
Nov-16	340	330	935	360	395
Dec-04	440	395	640	380	355
Dec-20	335	325	795	345	365

Table14

Calcium Hardness (mg/L-CaCO) Values for the Cedar River near the Duane Arnold Energy Center During 1995

Date 1995	Upstream of Plant	Upstream of Plant Intake	Discharge Canal	140 Feet Downstream of Discharge	1/2 Mile Downstream from Plant
	Sampling Locations				
	1	2	5	3	4
Jan-05	250	235	760	270	240
Jan-17	200	200	511	210	210
Feb-02	200	215	765	215	220
Feb-16	230	225	770	255	245
Mar-02	180	170	160	165	160
Mar-14	120	135	135	125	130
Apr-04	225	205	200	215	215
Apr-20	200	210	265	190	195
May-04	205	200	625	190	200
May-17	195	175	200	180	180
Jun-01	200	185	240	185	180
Jun-14	215	205	860	220	210
Jul-05	220	190	600	220	210
Jul-17	210	205	720	200	205
Aug-01	190	160	591	160	140
Aug-14	140	130	555	140	140
Sep-07	110	100	435	125	105
Sep-19	80	75	341	95	80
Oct-04	120	130	490	130	130
Oct-17	140	140	905	140	140
Nov-01	220	235	620	245	235
Nov-16	270	245	725	235	255
Dec-04	265	245	415	250	250
Dec-20	200	220	620	230	220

Table 15

Total Phosphorus (mg/L-P) Values for the Cedar River near the Duane Arnold Energy Center During 1995

	Sampling Locations				
Date 1995	Upstream of Plant	Upstream of Plant Intake	Discharge Canal	140 Feet Downstream of Discharge	1/2 Mile Downstream from Plant
	1	2	5	3	4
Jan-05	<0.1	0.1	0.9	0.1	0.1
Jan-17	0.1	0.1	0.5	0.1	0.1
Feb-02	0.1	0.1	0.6	0.1	0.1
Feb-16	0.2	0.2	0.9	0.2	0.2
Mar-02	0.3	0.3	0.3	0.3	0.3
Mar-14	0.6	0.6	0.5	0.6	0.6
Apr-04	0.2	0.2	0.2	0.2	0.2
Apr-20	0.2	0.4	0.6	0.2	0.2
May-04	0.2	0.2	0.7	0.2	0.2
May-17	0.3	0.3	0.4	0.3	0.3
Jun-01	0.3	0.3	0.6	0.3	0.3
Jun-14	0.3	0.3	1.2	0.2	0.3
Jul-05	0.3	0.3	0.4	0.3	0.3
Jul-17	0.3	0.3	0.9	0.3	0.3
Aug-01	0.2	0.2	0.6	0.2	0.2
Aug-14	0.2	0.2	1.4	0.2	0.2
Sep-07	0.2	0.2	1.8	0.3	0.2
Sep-19	0.2	0.2	2.1	0.3	0.2
Oct-04	<0.1	0.2	2.0	0.2	0.2
Oct-17	0.2	0.2	1.8	0.2	0.2
Nov-01	0.2	0.2	1.6	0.3	0.2
Nov-16	0.2	0.2	1.4	0.2	0.2
Dec-04	0.2	0.2	0.9	0.2	0.2
Dec-20	0.2	0.2	1.4	0.2	0.2

Table 16

Soluble Orthophosphate (mg/L-P) Values for the Cedar River near the Duane Arnold Energy Center During 1995

	Sampling Locations				
Date 1995	Upstream of Plant	Upstream of Plant Intake	Discharge Canal	140 Feet Downstream of Discharge	1/2 Mile Downstream from Plant
	1	2	5	3	4
Jan-05	<0.1	<0.1	0.4	0.1	<0.1
Jan-17	<0.1	<0.1	0.3	<0.1	<0.1
Feb-02	0.1	0.1	0.3	0.1	0.1
Feb-16	0.1	0.1	0.4	0.1	0.1
Mar-02	0.3	0.2	0.2	0.2	0.2
Mar-14	0.2	0.2	0.2	0.2	0.2
Apr-04	0.1	0.1	0.1	0.1	0.2
Apr-20	<0.1	<0.1	0.2	<0.1	<0.1
May-04	<0.1	<0.1	0.2	<0.1	<0.1
May-17	<0.1	<0.1	<0.1	<0.1	<0.1
Jun-01	<0.1	<0.1	0.1	<0.1	<0.1
Jun-14	<0.1	<0.1	0.5	<0.1	<0.1
Jul-05	<0.1	<0.1	0.4	<0.1	<0.1
Jul-17	<0.1	<0.1	0.3	<0.1	<0.1
Aug-01	<0.1	<0.1	0.2	<0.1	<0.1
Aug-14	<0.1	<0.1	0.7	<0.1	<0.1
Sep-07	<0.1	<0.1	0.6	<0.1	<0.1
Sep-19	<0.1	<0.1	0.4	<0.1	<0.1
Oct-04	<0.1	<0.1	0.9	<0.1	<0.1
Oct-17	<0.1	<0.1	0.7	<0.1	<0.1
Nov-01	0.1	0.1	0.6	0.1	0.1
Nov-16	0.1	0.1	0.6	0.1	0.1
Dec-04	0.1	<0.1	0.3	0.1	0.1
Dec-20	0.0	0.0	0.5	0.1	0.1

Table 17

Ammonia (mg/L-N) Values for the Cedar River
near the Duane Arnold Energy Center During 1995

	Sampling Locations				
Date 1995	Upstream of Plant	Upstream of Plant Intake	Discharge Canal	140 Feet Downstream of Discharge	1/2 Mile Downstream from Plant
	1	2	5	3	4
Jan-05	0.2	0.1	0.3	0.2	0.1
Jan-17	0.3	0.3	0.4	0.3	0.3
Feb-02	0.3	0.3	0.3	0.3	0.3
Feb-16	0.4	0.4	0.2	0.4	0.4
Mar-02	0.5	0.4	0.4	0.4	0.4
Mar-14	0.4	0.3	0.3	0.4	0.4
Apr-04	<0.1	<0.1	0.1	<0.1	<0.1
Apr-20	<0.1	<0.1	<0.1	<0.1	<0.1
May-04	<0.1	<0.1	<0.1	<0.1	<0.1
May-17	<0.1	<0.1	<0.1	<0.1	<0.1
Jun-01	<0.1	<0.1	<0.1	<0.1	<0.1
Jun-14	<0.1	<0.1	<0.1	<0.1	<0.1
Jul-05	<0.1	<0.1	0.1	<0.1	<0.1
Jul-17	<0.1	<0.1	0.1	<0.1	<0.1
Aug-01	<0.1	0.1	0.2	<0.1	<0.1
Aug-14	<0.1	<0.1	0.4	<0.1	<0.1
Sep-07	<0.1	<0.1	0.2	<0.1	<0.1
Sep-19	<0.1	<0.1	0.3	<0.1	<0.1
Oct-04	<0.1	<0.1	0.8	<0.1	<0.1
Oct-17	<0.1	<0.1	0.3	<0.1	<0.1
Nov-01	<0.1	<0.1	<0.1	<0.1	<0.1
Nov-16	0.2	0.2	0.6	0.2	0.2
Dec-04	0.2	<0.1	0.6	<0.1	0.2
Dec-20	0.3	0.3	0.3	0.3	0.3

Table 18

Nitrate (mg/L-N) Values for the Cedar River near the Duane Arnold Energy Center During 1995

Date 1995	Upstream of Plant	Upstream of Plant Intake	Discharge Canal	140 Feet Downstream of Discharge	1/2 Mile Downstream from Plant
	1	2	5	3	4
Jan-05	7.4	7.2	18	7.7	7.3
Jan-17	5.9	5.9	12	6.2	6.2
Feb-02	5.7	5.8	18	6.2	5.9
Feb-16	5.8	5.8	17	6.1	5.9
Mar-02	4.9	4.8	3.0	4.6	4.6
Mar-14	4.0	4.1	2.5	4.0	4.0
Apr-04	6.0	7.3	8.9	7.2	7.1
Apr-20	9.2	9.7	10	9.2	9.3
May-04	8.5	8.4	23	8.5	8.6
May-17	8.8	8.7	7.8	8.5	8.4
Jun-01	9.7	9.2	11	9.5	9.2
Jun-14	8.0	7.9	34	8.1	8.6
Jul-05	8.8	8.0	24	8.2	8.0
Jul-17	4.2	4.9	18	4.9	4.9
Aug-01	3.5	3.7	12	3.6	3.5
Aug-14	2.3	2.2	5.8	2.2	2.3
Sep-07	1.6	1.5	6.2	1.9	1.6
Sep-19	1.0	0.8	3.0	1.0	0.8
Oct-04	2.8	2.6	7.6	2.6	2.6
Oct-17	2.9	2.7	10	1.7	2.7
Nov-01	4.1	3.8	9.9	4.5	4.0
Nov-16	6.1	6.2	12	6.1	6.1
Dec-04	5.3	5.2	7.4	5.2	5.3
Dec-20	5.4	5.5	13	5.8	5.7

Table 19

Total Iron (mg/L) Values for the Cedar River
near the Duane Arnold Energy Center During 1995

Date 1995	Sampling Locations: Upstream of Plant	Upstream of Plant Intake	Discharge Canal	140 Feet Downstream of Discharge	1/2 Mile Downstream from Plant
	1	2	5	3	4
Jan-05	0.11	0.33	1.2	0.16	0.11
Jan-17	0.19	0.19	0.66	0.19	0.19
Feb-02	0.14	0.15	0.65	0.18	0.16
Feb-16	0.12	0.10	1.1	0.13	0.14
Mar-02	0.97	0.59	0.46	0.64	0.58
Mar-14	8.9	9.9	7.7	9.6	9.2
Apr-04	2.1	2.0	1.7	2.0	1.8
Apr-20	2.9	2.6	3.1	2.6	2.7
May-04	2.0	2.1	4.6	2.1	2.1
May-17	5.7	5.6	4.7	5.5	5.6
Jun-01	3.5	3.4	4.6	3.7	3.3
Jun-14	3.4	4.4	8.3	3.7	3.6
Jul-05	3.7	3.8	9.3	3.8	3.6
Jul-17	2.9	2.5	3.8	3.0	3.0
Aug-01	3.1	2.2	1.4	1.7	1.6
Aug-14	1.2	1.6	1.1	1.1	1.1
Sep-07	0.95	0.91	2.4	1.0	0.83
Sep-19	0.65	0.48	2.5	0.70	0.49
Oct-04	0.58	0.51	0.96	0.54	0.59
Oct-17	0.41	0.31	1.1	0.35	0.35
Nov-01	0.41	0.43	1.3	0.44	0.37
Nov-16	0.29	0.28	0.94	0.30	0.35
Dec-04	0.32	0.35	0.93	0.45	0.42
Dec-20	0.14	0.13	0.75	0.16	0.30

Table 20

Biochemical Oxygen Demand (5-day in mg/L) Values for the Cedar River near the Duane Arnold Energy Center During 1995

	Sampling Locations				
Date 1995	Upstream of Plant	Upstream of Plant Intake	Discharge Canal	140 Feet Downstream of Discharge	1/2 Mile Downstream from Plant
	1	2	5	3	4
Jan-05	<1	<1	1	<1	<1
Jan-17	1	2	3	1	1
Feb-02	2	<1	<1	<1	<1
Feb-16	<1	1	1	2	2
Mar-02	3	3	2	3	3
Mar-14	7	7	5	7	8
Apr-04	1	2	<1	2	2
Apr-20	1	2	7	1	1
May-04	3	3	6	3	3
May-17	3	4	3	4	3
Jun-01	3	4	6	4	4
Jun-14	3	3	3	3	3
Jul-05	2	2	5	2	2
Jul-17	5	5	8	6	6
Aug-01	6	6	9	6	6
Aug-14	9	10	14	9	10
Sep-07	10	10	11	10	11
Sep-19	11	10	18	11	10
Oct-04	10	11	14	11	11
Oct-17	8	7	12	8	8
Nov-01	3	3	4	3	3
Nov-16	2	1	2	2	2
Dec-04	1	2	2	2	2
Dec-20	1	2	1	1	2

Table 21

Coliform Bacteria (Fecal Organisms/100 ml) Values for the Cedar River near the Duane Arnold Energy Center During 1995

	Sampling Locations				
Date 1995	Upstream of Plant	Upstream of Plant Intake	Discharge Canal	140 Feet Downstream of Discharge	1/2 Mile Downstream from Plant
	1	2	5	3	4
Jan-05	30	<10	50	<10	18
Jan-17	70	70	440	100	70
Feb-02	40	30	64	72	73
Feb-16	36	60	20	110	36
Mar-02	73	50	<10	30	20
Mar-14	210	250	200	210	290
Apr-04	110	130	82	50	120
Apr-20	320	440	<10	210	290
May-04	160	73	260	55	91
May-17	1100	1000	700	1600	2000
Jun-01	220	230	340	100	390
Jun-14	230	220	1800	320	290
Jul-05	1000	1100	2900	2000	910
Jul-17	3900	5700	150	3800	3600
Aug-01	120	140	50	470	410
Aug-14	30	80	220	20	<10
Sep-07	60	45	900	40	130
Sep-19	260	180	2300	450	160
Oct-04	18	20	2000	110	90
Oct-17	18	30	860	10	30
Nov-01	170	82	1100	150	100
Nov-16	70	10	70	70	60
Dec-04	73	50	64	36	10
Dec-20	45	90	27	20	70

Table 22

Coliform Bacteria (E. coli/100 ml) Values for the Cedar River near the Duane Arnold Energy Center During 1995

Date 1995	Upstream of Plant 1	Upstream of Plant Intake 2	Discharge Canal 5	140 Feet Downstream of Discharge 3	1/2 Mile Downstream from Plant 4
Jan-05	10	10	70	<10	10
Jan-17	73	110	500	45	50
Feb-02	10	10	45	20	<10
Feb-16	40	10	20	20	40
Mar-02	40	10	10	10	<10
Mar-14	240	240	160	150	200
Apr-04	110	91	36	50	70
Apr-20	290	260	9	300	300
May-04	91	60	210	82	72
May-17	770	900	900	1700	2200
Jun-01	150	110	310	120	120
Jun-14	110	180	900	200	170
Jul-05	890	1300	1700	1200	1100
Jul-17	3700	5100	170	3500	3100
Aug-01	150	140	110	140	120
Aug-14	27	36	130	33	45
Sep-07	40	<10	300	30	60
Sep-19	60	110	5300	160	150
Oct-04	20	40	580	27	40
Oct-17	10	30	160	30	10
Nov-01	250	130	760	290	150
Nov-16	60	50	10	30	20
Dec-04	50	10	36	20	10
Dec-20	20	30	<10	<10	<10

Table 23

Additional Chemical Analysis-1995

Station	Cl^- (mg/L)	SO_4 (mg/L)	Metals (ug/L) Cr	Cu	Pb	Mn	Hg	Zn
			Apr-20					
1. Lewis Access	22	28	<20	<10	<50	110	<1	<20
2. Upstream DAEC	21	27	<20	<10	<50	100	<1	<20
3. Downstream DAEC	22	29	<20	<10	<50	110	<1	<20
4. One-half mile below plant	21	28	<20	<10	<50	110	<1	<20
5. Discharge Canal	36	226	<20	20	<50	170	<1	180
			Jul-05					
1. Lewis Access	18	24	<20	<10	<10	180	<1	20
2. Upstream DAEC	18	24	<20	<10	<10	190	<1	20
3. Downstream DAEC	20	33	<20	<10	<10	190	<1	30
4. One-half mile below plant	19	27	<20	<10	<10	180	<1	20
5. Discharge Canal	56	590	<20	20	<10	400	<1	210

Benthic macroinvertebrates collected on Hester-Dendy artificial substrates from the Cedar River and the discharge canal in the vicinity of the Duane Arnold Energy Center, 6/14/95-7/17/95.

Taxon	Lewis Access	U/S DAEC	D/S DAEC	½ mi. below plant	Disc. Canal
Nematoda	10	13	15	13	
Mollusca					
Gastropoda					
Limnophila					
Physidae					
Physa spp.					5
Arthropoda					
Arachnoidea					
Hydracarina	1		1		
Crustacea					
Malacostraca					
Isopoda					
Asellidae					
Caecidotea spp.					1
Insecta					
Coleoptera (Beetles)					
Elmidae					
Macronychus sp.				1	
Optioservus spp.		1			
Stenelmis spp.				1	
Diptera					
Athericidae					
Atherix spp.	3	1	1	1	
Chironomidae	2759	596	1103	764	18
Simuliidae					
Simulium spp.	59	2	3	35	1
Empididae					
Hemerodromia spp.	28	12	11	48	
Ephemeroptera (Mayflies)					
Baetidae					
Baetis spp.	13	41	29	39	
Caenidae					
Caenis spp.	21	70	92	61	1
Heptageniidae					
Heptagenia spp.	3	14		10	
Stenonema spp.		17	23	7	2
Oligoneuriidae					
Isonychia spp.		36	61	45	
Tricorythidae					
Tricorythodes spp.		5	38	26	
Odonata					
Coenagrionidae					
Argia spp.					3
Enallagma spp.					4

Table 24 (con't)

Taxon	Lewis Access	U/S DAEC	D/S DAEC	½ mi. below plant	Disc. Canal
Plecoptera (Stoneflies)					
Perlidae					
Acroneuria spp.		1		1	
Perlesta spp.		2		1	
Pteronarcidae					
Pteronarcys spp.		6	4	5	
Trichoptera (Caddisflies)					
Brachycentridae					
Brachycentrus numrosus		3	2		
Hydropsychidae (larvae)	1	12			
Hydropsychidae (pupae)		5	4	6	
Ceratopsyche morosa (bifida form)	3	1			
Cheumatopsyche spp.	12	8	6	10	1
Hydropsyche bidens	635	487	152	319	
Hydropsyche orris	172	23	16	32	
Hydropsyche simulans	45	66	55	40	
Hydropsyche spp. (immature)	43		10	59	
Potamyia flava	273	22	86	22	
Total Organisms	**4068**	**1444**	**1712**	**1533**	**36**
No. Organisms/m^2	**39,495**	**14,019**	**16,621**	**14,883**	**350**

Samples were collected using Hester-Dendy artifical substrate samplers. Samplers were composed of five plates measuring approximately 0.01 m^2 per side per plate.

Table 24 (con't)

Benthic macroinvertebrates collected on Hester-Dendy artificial substrates from the Cedar River and the discharge canal in the vicinity of the Duane Arnold Energy Center, 8/1/95-9/7/95.

Taxon	Lewis Access	U/S DAEC	D/S DAEC	½ mi. below plant	Disc. Canal
Mollusca					
Gastropoda					
Limnophila					
Physidae					
Physa spp.					9
Arthropoda					
Insecta					
Coleoptera (Beetles)					
Elmidae					
Optioservus spp.	1				
Stenelmis spp.	3	1	6		
Diptera					
Chironomidae	1879	895	722	742	8
Simuliidae					
Simulium spp.	6				
Empididae					
Hemerodromia spp.	6	1	1		
Ephemeroptera (Mayflies)					
Baetidae					
Baetis spp.	13	7		8	
Caenidae					
Caenis spp.	1	5	10	2	
Heptageniidae					
Stenonema spp.	18	20	5	4	
Oligoneuriidae					
Isonychia spp.	3	2	6		
Tricorythidae					
Tricorythodes spp.		1	4	1	
Megaloptera					
Corydalidae					
Corydalus spp.	1		3		
Plecoptera (Stoneflies)					
Perlidae					
Acroneuria spp.			1		
Attaneuria spp.		1			
Neoperla spp.	1				
Pteronarcidae					
Pteronarcys spp.				1	
Trichoptera (Caddisflies)					
Brachycentridae					
Brachycentrus numrosus	1				
Hydropsychidae (pupae)	228	62	37	21	
Cheumatopsyche spp.	6	3	2	3	
Hydropsyche bidens	411	133	99	157	
Hydropsyche orris	35	5	9	13	

Taxon	Lewis Access	U/S DAEC	D/S DAEC	½ mi. below plant	Disc. Canal
Hydropsychidae (cont.)					
Hydropsyche simulans	40	20	11	27	
Hydropsyche spp. (immature)	8	7			
Potamyia flava	842	238	89	85	
Total Organisms	**3,503**	**1,401**	**1,005**	**1,054**	**17**
No. Organisms/m^2	**34,009**	**13,602**	**9,757**	**10,233**	**165**

Samples were collected using Hester-Dendy artifical substrate samplers. Samplers were composed of five plates measuring approximately 0.01 m^2 per side per plate.

Table 25

Daily Numbers of Fish Impinged at the Duane Arnold Energy Center
January-December 1995

Day of the Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	0	0	1	0	0	0	0	0	1	0	4	1
2	0	0	0	3	0	0	0	0	0	0	0	3
3	2	2	0	0	0	0	0	0	0	0	0	5
4	1	0	0	4	0	0	0	0	0	0	4	0
5	6	0	0	2	0	0	0	0	0	0	2	0
6	0	0	2	1	0	0	0	0	0	0	2	6
7	0	0	0	0	0	0	0	0	0	0	2	8
8	1	1	0	0	1	0	0	0	0	0	8	6
9	0	1	0	0	0	0	2	3	0	0	1	0
10	0	0	4	0	0	0	0	1	1	0	3	2
11	2	1	3	2	1	0	1	0	0	0		4
12	2	0	7	0	0	0	1	2	0	0	13	7
13	6	0	5	0	0	0	2	0	0	0	0	11
14	3	0	*	0	0	0	0	1	0	0	2	0
15	1	1	3	0	0	1	0	0	0	0	4	3
16	2	0		0	1	0	0	0	0	0	0	14
17	0	0	2	0	0	0	0	0	0	0	6	11
18	0	0	2	0	0	0	0	0	0	1	3	4
19	0	0	1	0	0	0	0	1	0	0	4	2
20	0	1	6	3	0	0	0	0	0	0	4	3
21	0	0	3	1	0	0	0	0	0	0	1	0
22	0	1	2	2	0	0	0	0	0	0	5	0
23	0	1	0	1	0	0	0	1	0	0	4	1
24	0	0	0	0	0	0	0	0	0	0	2	2
25	0	12	0	0	0	0	0	0	0	0	3	0
26	0	0	1	2	0	0	0	0	0	0	2	3
27	0	0	0	0	0	0	0	1	0	0	6	0
28	2	4	1	0	0	0	0	0	1	0	0	2
29	3	-	0	0	0	0	0	0	0	0	1	2
30	0	-	0	0	0	0	0	0	0	2	2	3
31	1	-	0	-	0	-	1	1	-	6	-	1
Total	32	25	43	21	3	1	7	11	3	9	88	104
Annual Total	347											

*No Data

Table 26

Comparison of Average Values for Several Parameters at Upstream, Downstream, and Discharge Canal Locations at the Duane Arnold Energy Center During Periods Of Station Operation-1995

Parameters	Upstream (Sta. 2)	Discharge Canal (Sta. 5)	Downstream (Sta.4)
Temperature (°C)	11.9	14.7	12.3 (103%)*
Dissolved Solids (mg/L)	322	1295	337 (105%)
Total Hardness (mg/L)	290	841	291 (100%)
Total Phosphate (mg/L)	0.21	1.1	0.21 (100%)
Nitrate (mg/L as N)	5.5	13.3	5.6 (101%)
Iron (mg/L)	1.54	2.63	1.47 (96%)

*Percent of upstream level ()

Table 27

Comparison of Average Yearly Values for Several Parameters in the Cedar River Upstream of the Duane Energy Center*
1972-1995

Year	Mean flow** (cfs)	Turbidity (NTU)	Total PO (mg/L)	Ammonia (mg/L-N)	Nitrate (mg/L-N)	BOD (mg/L)	Total Hardness (mg/L)
1972	4,418	22	1.10	0.56	0.23	5.7	253
1973	7,900	28	0.84	0.36	1.5	4.0	250
1974	5,580	29	2.10	0.17	4.2	4.7	266
1975	4,206	58	1.08	0.33	2.8	6.5	251
1976	2,082	41	0.25	0.25	2.8	7.3	233
1977	1,393	15	0.33	0.52	2.9	6.5	243
1978	3,709	23	0.26	0.22	4.4	3.3	261
1979	7,041	26	0.29	0.12	6.6	2.5	272
1980	4,523	40	0.34	0.19	5.4	4.3	238
1981	3,610	33	0.77	0.24	6.0	6.5	279
1982	7,252	43	0.56	0.23	8.0	5.1	274
1983	8,912	22	0.25	0.10	8.6	3.3	259
1984	7,325	40	0.32	0.10	5.9	3.9	264
1985	3,250	30	0.31	0.11	4.8	6.7	245
1986	6,375	33	0.26	0.10	6.8	3.7	285
1987	2,625	32	0.24	0.06	5.6	5.8	269
1988	1,546	28	0.30	<0.16	2.8	9.6	246
1989	947	24	0.37	0.30	1.5	10.3	224
1990	5,061	33	0.29	0.20	7.3	4.8	283
1991	8,085	65	0.38	0.20	7.9	4.3	268
1992	5,717	49	0.31	0.16	6.4	5.5	261
1993	15,900	44	0.27	0.16	6.2	2.3	276
1994	4,701	34	0.28	0.22	5.1	5.3	269
1995	4,384	31	0.21	0.17	5.5	4.0	275

*Data from Lewis Access location (Station 1)
**Data from U.S. Geological Survey Cedar Rapids gauging station

Table 28

Summary of Relative Loading Values (Average Annual Concentration x Cumulative Runoff) for Several Parameters in the Cedar River Upstream of the Duane Energy Center*
1972-1995

Year	Mean Flow (cfs)	Cumulative** Runoff (in)	Turbidity	Relative Loading Values Total PO	Ammonia	Nitrate	BOD
1972	4,418	9.24	203	10.2	5.2	2	53
1973	7,900	16.48	461	13.8	5.9	25	66
1974	5,580	11.64	338	24.4	2.0	49	55
1975	4,206	8.77	509	9.5	2.9	25	57
1976	2,082	4.35	178	1.1	1.1	12	32
1977	1,393	2.91	44	1.0	1.5	8	19
1978	3,709	7.74	178	2.0	1.7	34	26
1979	7,041	14.79	385	4.3	1.8	98	37
1980	4,523	9.45	378	3.2	1.8	51	41
1981	3,610	7.53	248	5.8	1.8	45	49
1982	7,252	15.13	651	8.5	3.5	121	77
1983	8,912	18.00	396	4.5	1.8	155	59
1984	7,325	15.22	609	4.9	1.5	90	59
1985	3,250	6.80	204	2.1	0.8	33	46
1986	6,475	13.11	433	3.4	1.3	89	49
1987	2,625	4.85	155	1.2	0.3	27	28
1988	1,546	2.85	80	0.9	<0.4	8	27
1989	947	1.84	44	0.7	0.6	3	19
1990	5,061	9.34	308	2.7	1.9	68	45
1991	8,085	17.15	1115	6.5	3.4	135	74
1992	5,717	10.92	535	3.4	1.7	70	61
1993	15,900	32.39	1425	8.8	5.2	201	74
1994	4,701	10.45	355	2.9	2.3	53	55
1995	4,384	9.23	286	1.9	1.6	51	37

*Data from Lewis Access location (Station 1)
**Data from U.S. Geological Survey Cedar Rapids gauging station